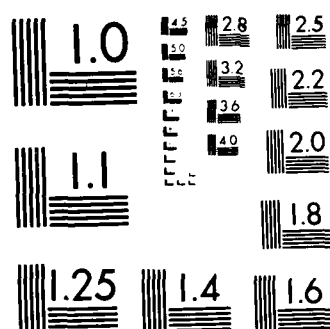MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

Report for the US Army research development and standardization group (UK).

Contract no. DAJA 45-85-C-0033

Requisition no. R & D 5133

Subject   Knowledge acquisition for expert systems in Construction

Principal investigator   Professor E G Trimble

Associated investigators   Dr R J Allwood. Mr A E Bryman

FOURTH INTERIM REPORT

(Covering the period 1 Sept 86 to 31 Dec 86)

15 January 1987

1. Introduction

Our letter to Dr Gault dated 17 November 1986 proposes that, as from
1 January 1987, our study of knowledge acquisition should be administered in
two parts, thus :

CERL : This part will concentrate on actual systems such as CRANES and BID/
NO BID. We shall report on our practical experience both in dealing
with the domain experts and in coding the acquired knowledge.

SERC : This part will draw more on other people's experience and will be
based largely on the profiling of situations in which expert systems
have been created and used.

This proposal was accepted by Dr Gault on 14 January 1987. This interim
report will therefore be the last that describes detailed work on the items that
will henceforth be administered under the SERC project. However the two projects
will continue side by side, joint progress meetings will be held, and we confi-
dently expect that each project will continue to benefit from the findings of
the other.

The remainder of this report is presented under the following headings.

Accession For

NTIS GRA&I

DTIC TAB

Unannounced

Justification

Availability Codes

Dist | Avail and/or Special

A-1

88 3 09 121

2. CRANES

The prototype CRANES system has been considerably improved over the last four months. The most significant developments which have taken place are as follows:

- Coding of the graphics module in Pascal and integration of this module with tne SAVOIR shell has been completed.
- Rules have been added which check for inconsistencies between crane requirements as determined by the graphics and hook time modules. The user is advised how he can amend the graphics or hook time data until an optimum solution is found. System messages include advice on whether pumping of concrete is required or whether all concrete should be placed by skip.
- Knowledge relating to division of the overall construction period between foundations, basement, superstructure shell and finishing trade phases has been added.
- Amplification and explanation text has been improved.

A very great deal of knowledge was acquired in the early stages of the work on cranes and the prototype system still only addresses a limited area of this. For this reason only one further knowledge acquisition session has been required since the last report. This session involved a demonstration of the prototype to two experts followed by an interview focussed on predefined topics.

The demonstration of the prototype elicited a very good response from the experts. Previous demonstrations have been of only the hook time module or graphics module in isolation and have prompted constructive comments but little real enthusiasm. The markedly better response to the latest demonstration resulted from the advice about cranage selection strategy which the system now gives to the user. It seems that the system is now perceived by the experts as being able to give some of the advice that they themselves would give, albeit in a limited area, rather than being merely a graphics or calculation tool.

A considerable amount of new knowledge was elicited during the latest session, partly from comments on the prototype system and partly from discussion of the preselected topics. Of particular interest was an exception to a rule about hook time in an area which we have vigorously pursued in previous meetings, and which we believed to be fully covered.

We now intend to develop the graphics module further and in particular to explore the linkage between the procedural graphics routines and the rule-base. Many rules have been elicited which involve spatial concepts or relationships. There seems to be an opportunity to develop the procedural code as a library of geometric handling routines. This will enable rules in the knowledge-base to derive information about spatial relationships directly from the coordinated model of the building. Examples of such information would be as follows:

- whether cranes have been located inside or outside the building by the system user.
- the maximum height of building which each crane must be able to overswing.
- the plan area of building overswung by each crane.

3. BID/NO BID

The prototype interpreter described in our last report has been demonstrated to a number of individuals within IDC Ltd. Various comments and suggestions have been made by these individuals·and the knowledge base has been refined accordingly. Initial development was carried out mainly with the co-operation of the Deputy Chairman, Mr Ivor Davies, who acted as our main expert. The reaction of the Sales Director, Mr Mike Stanton, to the prototype was positive and constructive. There was a good response from four of the company salesmen who were shown the system. Each salesman was asked to run the system for a job he was currently negotiating and his comments and criticisms were recorded in detail. The salesmen found the system useful because it forced them to consider all the factors relevant to the bid/no bid decision, some of which they might otherwise have ignored. The score for each consultation as calculated by the system was broadly in line with the expert's own judgement.

A particular criticism of the interpreter system was that it asked unnecessary questions. Perceived ambiguity in some of the questions also suggested that clarifying text should be available for the questions if required (following the convention of the SAVOIR shell we generally refer to this as "amplification" text).

We concluded that although the interpreter had been useful as a focus for the knowledge acquisition process there was now a need to code the system within a more sophisticated shell. Accordingly a new prototype system called BIDDER has now been developed using the SAVOIR shell. This has led to a much improved system as follows:

- Unnecessary questions have been eliminated.
- An explanation facility (of the reason for asking the current question) is now available.
- A why facility (i.e. why has this goal been reached) is now available.
- Amplification text can be easily inserted.
- In addition to the simple bid score, specific advice is now given such as "you should definitely bid" or "you should seriously consider bidding" etc.
- Advice is dependent on the range within which the final bid score lies. Once sufficient data is available to limit all possible outcomes to one of the critical ranges the system can reach a conclusion. Hence the system is often able to advise of an outcome without needing to ask all the available questions. (If this should occur the user is given the option of ending the consultation immediately or going through the remaining relevant questions).

- During the main section of the consultation the user can at any time review how the range of possible final scores has been reduced by the data that he has provided up to that point.

- The system records a checklist of the items which the user has indicated are not yet known. For example, if the user replies that the form of contract has not yet been agreed then the system will remind him at the end of the consultation that lack of this information has reduced the accuracy of the final score.

The SAVOIR shell has proved to be well suited to the domain knowledge so far acquired and we were able to rewrite the rules to form BIDDER in a little over two weeks. We plan to demonstrate this new prototype to IDC Ltd in the near future.

4. PARC

PARC is an acronym for Project and Resource Control. It is the name of a community club for expert systems set up by the British government's Department of Trade and Industry (DTI). At the time of writing the position is as follows

- Joint developers, BIT Ltd and BRAMEUR Ltd have been appointed

- At least eight organizations have joined as subscribing members and each has agreed to pay up to £10,000. The DTI will contribute a sum in excess of £100,000. The developers jointly will contribute £100,000.

- A point of central importance is that DTI require that the club should produce a usable end product. This contrasts with the stance adopted by the clubs established by the Alvey Directorate.

- A steering group has been formed and its Chairman and Deputy Chairman have been elected.

- Professor Trimble has attended four of the meetings held in the process of forming the club and has had private discussions with the developers.

- Agreement has been reached in principle that a "Technical advisory council" should be established. In the event, finding suitable academics with knowledge about both project management and expert systems has proved difficult. It is possible that Professor Trimble will therefore be the only academic participant.

Bit Ltd have previously produced a package called PARYS which is a knowledge-based system to help in personnel selection and in identifying the training needs of selected personnel. It seems likely that they will use this software as a starting point for the system(s) to be developed for PARC.

Professor Trimble will be required to sign a confidentiality agreement as a condition of his participation. It is hoped that the agreement will allow us to report in future on matters of concept as distinct from data. The category of "data" is likely to include actual knowledge bases that will be developed by the club.

We believe that our involvement may bring us some valuable insight on the strategy by which potential users can be identified and mobilized on a collaborative basis. Insight may also be reached regarding the methods of communication and knowledge acquisition appropriate to this "developer/club" form of organization.

We understand that the developers propose to use a heavily structured approach to knowledge acquisition. We hope to monitor selected applications so that a comparison can be made with the deliberately less-structured approach we ourselves have adopted.

5. A possible new domain

We have been involved in discussions with Foster Wheeler Power Products Limited about a possible new domain for development of a knowledge-based system. Our main contact is Mr Martin Allen, Manager, Engineering Computer Systems. Mr Allen is very enthusiastic about the possibilities for knowledge-based systems in the company. However he has recognized that in order to get such systems accepted a prototype is required which can be demonstrated widely within the organization. This first system must be successful - otherwise the whole idea of knowledge-based systems could be rejected by the company.

So far we have discussed one domain in some depth, a system to diagnose faults during the commissioning of large boilers. This domain was suggested by a project manager as a means of remedying the shortage of experienced commissioning engineers which is a problem at times of high workload. We discussed the domain with the manager of the Test and Servicing Department and also with a highly experienced commissioning engineer (who would be a suitable expert for this domain). The main points raised during our discussion are presented below in some detail since we feel that this initial assessment of the domain highlights some important issues.

(i)   The overall commissioning procedure can take anything from six weeks to one year dependent on the complexity of the installation. It can be viewed in two parts - pre-commissioning and commissioning. Pre-commissioning starts when assembly is complete. It consists of the test engineer checking that the plant has been assembled to the drawings - all parts are installed, valves are fitted the correct way round, fans turn the correct way etc. The actual commissioning procedure then takes place during which the plant is brought to life. The first activity is more akin to following a checklist and a manual is in preparation for this. The diagnosis of faults from symptoms occurs during the latter stage.

(ii)   The boiler systems are individually designed and highly customised (although all include the same basic elements). They are complex and intimidating, and were described to us as "like cathedrals". As well as mechanical parts - burners, boiler, pumps, fans, lubrication systems, conveyor, dust control system etc, etc - the commissioning engineer must also be able to deal with the control

panel and associated micro-processor systems and control software. For this reason commissioning engineers often work in pairs with different specialists.

We looked at some of the weekly Test and Service reports produced by the commissioning engineers and these confirmed the complexity of the work.

(iii)   Foster Wheeler employ about twelve experienced commissioning engineers. They have learnt their skill through long experience rather than formal training and none of them has degree level qualifications. New trainees are now generally graduates. It takes them two years of following an experienced engineer around a site just to learn their way around the plant. They need a further ten to twelve years in the job before they can be regarded as experienced.

(iv)   An extreme example of a fault on a power station was quoted to us. A temperature sensor on a boiler continually "tripped" the boiler off by intermittently indicating a dangerously high reading. Eventually this was traced to an earth leakage fault. It took three months to diagnose the cause of the fault and cost Foster Wheeler £250,000.

(v)   Although they recognised that there are periodic shortages of commissioning engineers, neither of the people we spoke to could visualise how a knowledge-based system could be used in this context. They did not think that such a system could enable the existing experts to work more quickly, and they also felt that if used by a novice the system would be no substitute for the extensive detailed experience which was found necessary as training for the commissioning engineers.

(vi)   The first reaction from the expert when told of the proposal for a knowledge-based system was "You're going to automate my job". There would inevitably be resistence from the experts if they perceived the system as something which could replace them.

Our conclusion was that the commissioning of large boilers would not be a suitable domain for us to tackle at this stage for two reasons. Firstly the participants we talked to were not able to say what the system should do, who would use it or when it would be used. We regard the answering of these questions as an essential prelude to knowledge-based system development. Secondly the domain is clearly extremely complex and in the time we have available we believe that we could not complete the work to a convincing point. We should not wish to jeopardise the future development of knowledge-based systems in Foster Wheeler by producing a prototype which was perceived as trivial in the domain it was intended for.

Two more domains have been proposed within the company and we shall be investigating these as soon as meetings can be arranged with appropriate experts. These involve the production of welding specifications and the diagnosis of the cause of the tube failure in boilers. We understand that the experts are in both cases enthusiastic about the idea of a knowledge-based system. In the former case such a system is seen as a means by which a routine but excessive workload experienced by the experts can be delegated to draughting staff

6. Verification of BREDAMP

About 12 months ago we produced an expert system to diagnose the cause of dampness in buildings. This was commissioned by the Building Research Establishment and is referred to as BREDAMP. This system has received some acclaim from construction academics but has not been installed as a practical advisory tool. We accordingly persuaded BRE to commission us to conduct trials of the system and to report on its potential market. This evaluation commenced in October 1986. and is substantially complete. Some of the results are relevant to the work we are undertaking for CERL and we expect to report on these results when clearance has been obtained.

7. Alternative knowledge acquisition methods

The original intention as part of our wider programme of investigating methods of Knowledge Acquisition using case studies was to mount a comparative evaluation of Knowledge Acquisition methods by adopting a well structured experimental research design. This research design involved developing Expert Systems within a single domain, using the following methods:

i   Knowledge Acquisition by questionnaire sampling

ii   Knowledge Acquisition by machine induction

iii   Knowledge Acquisition by rapid prototyping

iv   Knowledge Acquisition by classical elicitation arrangements using a
         variety of interview techniques, including structured, focussed,
         and repertory grid methods.

The domain selected was a system to advise on the appropriate method of planning for projects. The intention was to develop the working Expert System for each method and then to evaluate each method retrospectively using rating scales and an evaluation panel of experts.

For both practical and theoretical reasons, we now consider it advisable to re-direct the orientation of this strategy. Having mounted a questionnaire survey of some 90 project managers, receiving only 4 completed replies, we feel that such a poor response significantly undermines the integrity of the original research design. In addition we now have further evidence from our continuing evaluation of Expert System applications, that many applications do not follow a single acquisition process, but adopt a multiplicity of methods (typically beginning with unstructured interviews, followed by fast prototyping, followed by more detailed interviews).

We believe that the reality of Knowledge Acquisition presents our original highly structured research design in a rather artificial light, making it difficult to evaluate each method in the scientific way we originally intended.

In these circumstances we are preparing a revised strategy for this investigation. We plan to implement it using SERC funds but hope, as indicated in section 1, that the results can eventually be made available to CERL.

8. Rule induction

As previously reported we have assigned a low priority to this topic. However we have received information that confirms that B.P. Plc. continue to make progress with their applications of rule induction and we hope to obtain further details.

We remain convinced that a short visit to Loughborough by Dr Rense Lange would be valuable.

9. Future work

With CERL funding we plan to continue our work on CRANES and BID/NO BID, and to start a new domain with Foster Wheeler. We plan to continue our work on BREDAMP and our association with PARC and shall report as circumstances permit. We shall develop and implement a revised strategy for exploring alternative knowledge acquisition methods. This last item of work will be funded by SERC but we hope to be able to report to CERL on significant findings.

END

DATE
FILMED
6- 1988
DTIC